A RAPID ASSESSMENT TOOL FOR EMPLOYMENT LOSSES AFTER AN EARTHQUAKE

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A rapid assessment tool for employment losses after an earthquake*

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Abstract

This article develops a rapid assessment tool to predict employment losses in the event of an earthquake. The tool benefits from an unique dataset at neighborhood level from the earthquakes that occurred in Türkiye during February 2023. This dataset allow us to investigate the predicting power of different types and area levels of building damage as well as of the prevailing employment structure. The predictions of the recommended specifications are then tested against actual data finding that even the simplest ones can capture relevant patterns regarding employment losses.

Keywords: Earthquake impact, employment losses, diagnostic tool.

J.E.L. Classification: J-21 H-12 H-84.

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1 Introduction

Earthquakes are capable of provoking massive economic losses as well as deaths. As such, accurate assessments of such losses in the aftermath of a disaster are crucial for an effective response and recovery. The employment losses that occur after an earthquake, even though part of the overall economic losses afflicting the affected region, carry particular importance from a sociological point of view. They are, in fact, a potential source of future poverty that may even impede the return to normal in spite of efforts to rebuild basic infrastructure. Despite its importance, hours of work lost are insufficiently covered in existing rapid assessment tools. This hampers efforts to allocate resources efficiently by policymakers and international organizations as well as to tailor support programs adapted to the scale of the disaster.

This article fills this gap in the literature by presenting a diagnostic tool for the estimation of employment losses after an earthquake. It does so by building a neighborhood-level database with building damage, employment losses and population density collected in the area affected by the 2023 earthquakes of Türkiye. This unique database builds on the strength of the Turkish administrative efforts to produce a building by building damage assessment, the joint efforts of the ILO and IOM to carry out a household survey in the affected area and the decade long effort of the Turkish Statistical Institute in creating a country wide grid to classify the more than 50,000 neighborhoods of the country based on their population density.

Existing diagnostic tools tend to focus on economic losses without including employment losses. For instance Chen & Zhang (2022) presents an automated machine learning framework that aims at predicting both, casualty rates and economic losses. In Türkiye, Kundak (2004) estimates the economic losses of a potential earthquake in Istanbul using a loss estimation model. The explicit inclusion of losses induced by the interruption of economic activities is remarkable but the study is more of an ad-hoc case for Istanbul than a generic, available, diagnostic tool. An exception that focuses on employment losses can be found in Pinedo (2023). In his work an ad-hoc model is proposed to cater for the characteristics of the 2023 February earthquakes that took place in Türkiye although the strong assumptions taken overshoot predicted employment losses twofold in comparison with the results of our diagnostic tool.

Likewise, post-earthquake assessments also tend to focus on economic losses and deaths. This area of knowledge is, indeed, well developed thanks to the European Environment Agency, who maintains the CATDAT. Instructions on how to use this extensive database available in Daniell et al. (2012). Although in terms of post-disaster assessments it is possible to encounter labour market losses. For instance, in Türkiye a mid-term (almost 1 year) analysis has been done by Dolu & İkizler (2023) for previous earthquakes in the country. In their article they estimated the impact of earthquakes in the labour market by means of a counter-factual made of regions not affected by the earthquakes. In addition, they use data on unemployment benefit applications and the number of job placements to prepare the analysis. Unfortunately the sources of data mean that the informal sector may not have been covered, a feature we attempt at doing with our new diagnostic tool. Interestingly, these authors suggest a 4 month period before a full recovery in activity for notably smaller earthquakes than the ones occurred in February 2023. Another study that uses a similar regional strategy to serve as a counter-factual is Pietro & Mora (2015). In this article the authors perform difference in differences to assess the impact of L'Aquila earthquake (Italy) on labour market outcomes. Basile et al. (2021) is another example studying mid-term effects of L'Aquila earthquakes. An example from Japan regarding the impact of earthquakes in the labour market can be found in Higuchi et al. (2012) pointing out a worrying mismatch between applicants and job offers in the most affected region. An example for the US is Kroll et al. (1991) who prepares an assessment for the 7.1 magnitude earthquake that struck Loma Prieta (US) in 1991. The impact of the earthquake suggests an increase in informality, in line with the findings of Mendoza & Jara (2019) for Ecuador as well as the findings of the ILO/IOM survey for the Türkiye February 2023 earthquakes.

Methodologically speaking this article differs from other labour market assessments because it is designed to measure employment losses in every place struck by an earthquake, ie the tool is not country-specific and the data demands are lower. Of course, country-specific information on employment losses could be found out by carrying out surveys yet it is likely, at least in the short-term, that those surveys are feasible given the conditions on the ground. Something similar happens with administrative data; it is unlikely that it will be either quickly updated nor to include informal employment. In this sense, our tool is devised to bring more comprehensive information faster to those who need it. Moreover, we have not found other diagnostic tools that put employment losses under the spotlight. It is important to note that our diagnostic tool focuses on short-term job losses and, therefore, no counter-factual strategy is designed, ie we assume the labour market would continue performing as it was at the time of earthquake given the short time span. Last but not least, the diagnostic tool is prepared to report on hours of work lost, rather than employment, using the lessons learned by the ILO during the pandemic. See the change in ILO (2020) worldwide and Pinedo (2021) for the relevant assessment in Türkey.

This research is of special importance to the International Labour Organization, who is already a relevant partner in Post-Disaster Needs Assessments or PDNAs as it was shown during the earthquake of Türkiye 2023 and in many other places around world. Moreover, the ILO enacted the 'Employment and Decent Work for Peace and Resilience Recommendation' or R205 in 2017. The recommendation underscores that effective disaster management should prioritize employment creation and the protection of workers' rights, especially in vulnerable communities. It also calls for integrating labor considerations into disaster risk management which is, precisely what this diagnostic tool aims at facilitating. Moreover, the ILO has also shifted its focus and increased its engagement in the humanitarian-development nexus. This nexus is vital for promoting a sustainable and inclusive recovery in the aftermath of crisis. This approach ensures that employment and decent work considerations are fully integrated into relief efforts and recovery planning with an aim on higher ambitions regarding sustainable development goals and social justice.

The performance of the diagnostic tool is tested against actual data on employment losses from the 2023 February earthquakes that occured in Türkiye. At that time two strong earthquakes, with the initial one occuring in Pazarcık and the second replica in Elbistan, shook the ground on February 6 resulting in more than 50,000 victims and more than 200,000 buildings lost. We also expand the existing knowledge regarding the employment losses caused by these earthquakes by estimating the impact at the district level for 68 such districts.

2 Data sources

Back in February 2023, right after the earthquakes, 11 provinces were declared under emergency by the Turkish government, which shows the magnitude of the disaster. In the end, not all provinces were equally damaged, with some only showcasing minor disruptions, and, as such, this article focuses on the four provinces that were most affected by the earthquake, namely Adıyaman, Hatay, Kahramanmaraş and Malatya as well as on three nearby provinces, namely Gaziantep, Osmaniye and Kilis that endured moderate damage. There is no data on employment losses for the last three provinces because the ILO/IOM household survey (the source of hors of work lost) did not took place in them for budgetary/relevance reasons. However, given the geographical proximity, the vast damage hold in districts such as Nurdağı or Islahiye and for the purpose of informing the public they are added to the database so as to predict (what is called an out of sample prediction) the impact of the earthquake on these provinces' employment levels in the section devoted to applying the diagnostic tool to Türkiye's 2023 earthquakes.

Türkiye is administratively speaking split into 81 provinces (NUTS3), 923 districts or sub-provinces (LAU1) and 50,538 villages and neighborhoods (LAU2).[1] This information is of special importance as our database encompasses information at different geographical levels. At the neighborhood level (LAU2) there is data on building damage, degree of urbanization, total population and the share of hours of work lost after the earthquake. In addition, data on the of share of informal workers and the share of employment in agriculture is available for central and non-central districts (LAU1) in each province.[2] It should be noted that data on hours of work lost is scarce. It comes from interviews and is only available for a small subset of neighborhoods from the four most affected provinces. The remaining neighborhoods are included so as to perform an out-of-sample prediction.

Ministry of Urbanization. First and foremost, data on building damage is retrieved from the Ministry of Environment, Urbanization and Climate Change of Türkiye.[3] This data is made publicly available by the ministry[4] and contains, as of June 2023, the results of visits by experts to 2,108,010 buildings in more than 10 provinces affected to a varying degree by the earthquake. As it can be

[1] No distinction is drawn between villages and neighborhoods in this article. The size is similar and the trend is that villages will be extinguished overtime and turned into neighborhoods.
[2] Central districts are known as *merkez ilçe* in Turkish.
[3] In Turkish known as Çevre, Şehircilik ve İklim Değişikliği Bakanlığı.
[4] See https://hasartespit.csb.gov.tr/#!/ although a Turkish IP address is needed to access it.

seen in Table 1, 34,320 buildings collapsed, with 17,535 being declared to be urgently demolished and 160,651 were found to have heavy damages. These three categories were declared as unusable by the government due to the danger posed to its inhabitants, while its demolition was ordered in the short or mid-term. This 'unusable' category carries special importance in the context of job losses as all three damage types are associated with a loss of workplaces or usual residences, thus, hindering the chances of a continuation in employment.

Table 1: Building damage, database summary.

Assessment result	*Total*	*Percentage*	
No damage	1,131,059	53.7	
Light damage	485,025	23.0	
Medium damage	30,268	1.5	
Heavy damage	160,651	7.6	Unusable
To be urgently demolished	17,535	0.8	Unusable
Collapsed	34,320	1.6	Unusable
No assessment possible	89,179	4.2	
Outside of the scope	159,973	7.6	
Total	2,108,010	100.0	

Note: The table shows the number of buildings in each damage status from 15 provinces. Some provinces, the ones with least damage, were not assessed comprehensively. Unusable buildings are those whose entry was forbidden by the government and, thus, could not be use by its inhabitants. These buildings include the three categories shown in the table.

As for the four most affected provinces,[5] Table 2 shows the sheer increase in the percentage of unusable buildings in comparison with the overall damage data. For instance, 25.6 per cent of the residential building stock of Adıyaman was lost. There are also qualitative differences in terms of damage type that are worth mentioning, such as the 5.4 per cent and 4.2 per cent of collapsed buildings in, respectively, Adıyaman and Hatay. These shares of collapsed buildings are even higher in the most affected districts and probably explain some of the high casualties' figures. However, precisely for possibly being a predictor of casualties, collapsed buildings not be the best predictor of employment losses since the chance of collecting information from survivors diminishes.

The damage is available at the building level, but it is aggregated at the neighborhood level for 3,957 such units[6] as well as at the district level (68 districts) for analysis purposes. In addition, an *extended neighborhood* damage variable is also created at the neighborhood level. It is defined as the damage held by all neighborhoods that share a common border with the neighborhood under analysis (whose damage is also included). These extended neighborhoods are created to offer an intermediate area impact as the neighborhood damage may not reflect well workplace destruction if located in a

[5] Please, note that for space reasons we omit information on building damage of the three nearby provinces, Gaziantep, Kilis and Osmaniye. Damage levels are sensibly lower, predictions are shown for completeness in the results section and have no effect on the diagnostic tool.

[6] The neighborhoods of the four provinces under analysis plus the three nearby provinces under analysis for which no data on hours of work lost exist.

residential area and district level damage may, perhaps, be too broad.

The number of buildings with damage in each neighborhood/extended neighborhood/district is later converted into shares. For instance, the share of buildings of a particular neighborhood that are unusable is defined as the sum of all unusable buildings divided by the total number of buildings in the neighborhood (including those where the assessment was not possible and those outside of the scope). The same can be said of the share of buildings unusable in a particular district.

Table 2: Building damage, four most affected provinces.

Assessment result	*Adıyaman*	*Hatay*	*Kahramanmaraş*	*Malatya*
No damage	32.7	41.3	41.7	33.7
Light damage	28.8	29.5	27.2	25.0
Medium damage	5.1	2.2	1.2	0.6
Heavy damage	18.4	15.6	13.2	17.8
To be urgently demolished	2.0	2.4	2.1	0.9
Collapsed	5.2	4.2	3.4	2.8
No assessment possible	2.4	0.8	4.8	6.4
Outside of the scope	5.4	3.9	6.5	12.8
Total buildings	106,422	302,984	190,173	165,671
Population (pre-earthquake)	604,978	1,544,650	1,116,618	742,725

Note: The table shows the share of buildings in each damage status for the 4 affected provinces as well as the total number of buildings. The pre-earthquake population (ABPRS 2022) is included to give a sense of the proportion between buildings and people.

ILO/IOM survey. Labour market information is retrieved from the ILO/IOM household survey that took place in the four most affected provinces in February and March 2024, i.e. a year after the disaster. Information on how and where the survey was carried out is offered in Appendix A. Technical details aside, the survey included a recall module where household members are asked whether they were working before the earthquake or not, and if the did so, whether they work less hours than before or they lost their job altogether after the earthquake. For the purpose of the analysis individuals are representing themselves, i.e. no survey weight is used as the survey does not have representativeness neither at the neighborhood level nor at the district level. Given that families were chosen at random, the share of hours of work lost at a particular neighborhood is calculated as the simple average of the individual hours of work lost. Moreover, since the answers are partly qualitative (worked less hours than before), it is assumed that those claiming no change in working hours lost 0 hours, those who claimed that were fired/lost their job lost 100 per cent of their working hours and those who worked less than before are assumed to have lost 50 per cent of the hours worked.

It should be noted that we use the neighborhood where the person was living *at the time of the earthquake* not the neighborhood where the interview took place. Otherwise we could have matched damage and hours of work lost in different neighborhoods, thus potentially rendering any potential

Table 3: Hours of work lost, shares and number of respondents.

	% hours of work lost			
Province	*0*	*50*	*100*	*Total obs.*
Adıyaman	51.9	9.9	38.2	589
Hatay	48.6	6.2	45.2	935
Kahramanmaraş	67.5	9.4	23.1	661
Malatya	71.6	7.8	20.6	486
All four provinces	58.2	8.1	33.7	2,671

Note: The table shows the share of individuals with a given loss of hours of work by province. The total number of individuals who were working before the earthquake is also shown. In terms of the data, those reporting '0' means they continued working as usual.

relationship between hours of work lost and damage spurious. This extent applies in particular to those living in container areas at the time of the interview as these individuals were usually living in other places before the earthquake.

In the four provinces where the survey was carried out there are 2,653 neighborhoods. However, the workers surveyed in the sample come from 365 of them (13.8 per cent) and only data from 44 (1.6 per cent) is actually used due to the low number of responses (at least 15 interviews in a neighbourhood is taken as the cut off threshold) in most pre-earthquake neighborhoods. The individual responses are aggregated at the neighborhood level assuming, as it stems from the survey sampling method, that these families were chosen at random.

In addition, we use the survey weights of the survey to retrieve the share of informal workers and the share of workers in the agricultural sector to be used as independent variables in the regression analysis. The information is retrieved for central and non-central districts (8 such units in total). This information could have been retrieved from the national labour force survey but the geographical level available (NUTS2) is higher than the one available one in the ILO/IOM survey (between LAU1/NUTS3), and, thus, the latter is preferred.

Turkstat and Ministry of Defense. The Turkish Statistical Institute[7] is the data source of the degree of urbanization and total population. Of particular relevance is the data regarding the rural/urban classification as the institution reported on the degree of urbanization of the country's more than 50,000 neighbourhoods/villages using EUROSTAT standards. Based on these standards a classification where neighborhoods are defined as rural, medium density towns and high density cities,[8] is created.[9]

Information on the degree of urbanization and total population is taken for the 3,957 neighborhoods present in the database from all seven provinces under analysis. Table 4 reports the prevalence of each

[7] Türkiye İstatistik Kurumu or TÜİK.
[8] In the original Turkish Kır, Orta yoğun kent and Yoğun kent.
[9] The degree of urbanization generates a variable similar to DEGURBA, https://ec.europa.eu/eurostat/web/degree-of-urbanisation/information-data.

urbanization category for the four most damaged provinces. It is worth noting the higher dispersion of the population of Hatay in comparison with that of the other three provinces, where the population tends to be concentrated around their capitals. In addition, data on area size at the district level is taken from the General Directorate of Mapping[10] in order to calculate the population density of the 68 districts present in the database.

Table 4: Population density, summary statistics.

	Degree of urbanization			
Province	*Rural areas*	*Town/suburbs*	*Cities*	*Neighborhoods*
Adıyaman	86.9	6.2	6.9	628
Hatay	46.0	28.0	26.0	593
Kahramanmaraş	74.9	11.8	13.3	713
Malatya	84.4	3.9	11.7	719
All four provinces	73.9	12.0	14.1	2,653

Note: The table shows the share of neighborhoods with a given degree of urbanization by province. The total number of neighborhoods is also shown.

3 Diagnostic tool development

3.1 Model specification

An econometric model is developed so as to explain short-term employment losses after an earthquake. Employment losses, the dependent variable, is measured as the share of hours of work lost after the earthquake. The variable is bounded between 0 to 1 and is used at the neighborhood level. Given the bounded nature of the dependent variable a fractional regression model is envisioned to explain the variation in hours of work lost. The baseline model is specified as

$$\text{Hours lost} = \Phi(\text{Damage}, \text{Urbanization}, \text{Informality}, \text{Agriculture}), \tag{1}$$

where Φ is the link function that represents the inverse of the cumulative distribution function of the normal distribution and hours lost refer to the share of hours of work lost after the earthquake. As for the independent variables urbanization refers to the degree of urbanization of the neighborhood and it is used as binary variables that takes the value 1 when the neighborhood has a high and a medium degree of urbanization, leaving low urbanization out as the reference. Informality and employment in agriculture are intended to represent the local employment structure. The former is borught as the share of workers who are not registered in the social security institute while the latter is used as the share of workers in the agricultural sector, both measured at the district level. Last but not least, damage is also measured as the share (bounded between 0 to 1) of buildings with a particular

[10] Harita Genel Müdürlügü.

damage intensity. This variable is not restricted to remain at the neighborhood level, in fact, three levels are defined, neighborhood (LAU2), extended neighborhood and district (LAU1). The extended neighborhood is defined as all the neighborhoods that share a common border with the neighborhood under analysis (which is also included) and, in practice, typically covers around 6 neighborhoods. As a comparison point, districts tend to include approximately between 50 to 100 neighborhoods.

Testing the role of damage. The fact that building damage has an impact on employment is out of question, even if just for the job losses that would be created due to the destruction of workplaces. It is unclear, though, whether the destruction of a purely residential neighborhood would have an equal impact on employment, if, say, nearby commercial areas are left untouched. The location of commercial areas is not available yet the existence of three geographical levels of destruction may shed some light into this question.

In addition, our database is rich enough to include the severity of the destruction, with the share of buildings with heavy damages, the share of buildings to be demolished soon and the share of buildings that collapsed all being available. This allows us to test for differences between damage types in terms of relevance.

Both, the severity of the damage and geographical level are tested in Table 5 with regards their relationship with employment losses. The tests are one on one regressions between each of the available severity and geographical levels of damage, nine in total, and employment losses. Based on the results it can be concluded that most measures are strongly correlated with hours of work lost. However, the strength of the relationship is weaker regarding damage at the neighborhood level and, thus, district and extended neighborhood level damage seem to be stronger predictors of hours of work lost. This might be because higher-level damage variables measure better the effect of the earthquake on companies and workplaces. This seem to confirm the hypothesis that if a small residential neighborhood were to be badly damaged within a large, undamaged, city, there should not be dramatic employment losses in that neighborhood other than for deaths - and the hours of work lost of the deceased ones are not measured in our database.

Table 5: Fractional regression: Testing damage typology

	Damage type			
Damage geographical level	*Heavy damage*	*To be demolished*	*Collapsed*	*Unusable*
Neighborhood	0.93**	3.54**	1.02	0.65**
Extended neighborhood	2.02***	7.39***	7.18***	1.51***
District	4.29***	17.7***	8.85***	2.73***
Obs.		44		

Significance: *** at 99%, ** at 95%, * at 90%.

The correlations provided also suggest that not so extreme damage variables (ie heavy damage) seem to be have stronger links with employment losses, perhaps due the higher stability of the variable in comparison with the inter-neighborhood variation of the share of collapsed buildings. The effect on employment losses also grows larger the higher the intensity of the destruction, pointing at the relative scarcity of collapsed buildings and buildings that need to be demolish soon. The parameter estimates of the fractional regression model do not have a direct interpretation but the marginal effect of a 1 percentage point increase in unusable buildings is associated to an almost equal increase in the share of hours of work lost, suggesting the existence of a linear, one-to-one relationship at least at the available damage levels.

Testing of other key variables. As it stems from Dolu & İkizler (2023), earthquakes in Türkiye are more likely to damage employment in the services' sector, which, in turn, tends to be stronger in urban settings and boasts higher informality. Therefore, in addition to the damage typology, the relevance of population density and the employment structure is also tested. Regarding the employment structure both, the share of informal employment and the share of employment in the agricultural sector are also added to control for the structure of the local labour market. Agricultural employment is expected to have a negative correlation with employment losses as the country side is not expected to be damaged other than for the fault line. As for population density, the new specifications test the addition of two binary variables called medium density and *high density* that takes the value 1 when the neighborhood holds the respective density category and leaves neighborhoods with a low degree of urbanization as the reference point. In addition, damage is also allowed to have a non-linear effect on hours of work by adding a quadratic term o the regression. This is to test for the possible existence of a damage threshold that once surpassed has a multiplicative effect on economic activity losses.

The results of adding the aforementioned pieces of information, including variables related to the employment structure and to the degree of urbanization, are shown in Table 6.[11] The results when using neighborhood level damage are disappointing and the estimates are not statistically significant at any of three confidence levels tested. In principle a larger sample size, could, perhaps, lower the standard deviation of some of the estimates yet still the neihbourhood level does not seem to provide reliable predictors of employment losses.

In turn, the extended neighborhood as well as the district level damage variables do a better job at explaining hours of work lost with the coefficients constantly shown strong (statistically speaking) relationships with job losses. Province level damage is also tested and since the results (not shown) do not provide any sound basis for estimating employment losses it is concluded that the sweet spot for the best predictor lies somewhere between the extended neighborhood and the district level. This is good news in the context of building a diagnostic tool, since the aim is to produce the simplest specification with the easiest to collect information.

As for the other variables tested, it can be argued that the quadratic term can be disregarded and

[11] Appendix C provides the same results for a smaller sample. Such sample would have been obtained if were to restrict neighborhoods with at least 20 respondents instead of 15 thus, testing the robustness to small sample size changes.

Table 6: Fractional regression - Other tests.

Damage level	*Variable*	Spec.1	Spec.2	Spec.3	Spec.4
Neigh.	*Unusable*	0.38	0.36	0.86	0.57**
	Unusable^2			−0.27	
	Low density, reference				
	Medium density		−0.024		
	High density		0.41**		
	Agriculture	−0.04			
	Agriculture^2	0.0006			
	Informal				0.020*
Ext. Neigh.	*Unusable*	1.37***	1.24***	2.89**	1.43***
	Unusable^2			−2.01	
	Low density, reference				
	Medium density		0.021		
	High density		0.34*		
	Agriculture	0.021			
	Agriculture^2	−0.0016			
	Informal				0.013*
District	*Unusable*	3.06***	2.49***	2.52	2.62***
	Unusable^2			0.36	
	Low density, reference				
	Medium density		0.18		
	High density		0.38**		
	Agriculture	0.08**			
	Agriculture^2	−0.004***			
	Informal				0.012
	Observations		44		

Significance: *** at 99%, ** at 95%, * at 90%.

the effect of damage on employment losses seems to be linear. In addition to the results shown in Table 6, linear regression estimates of the same equations are shown in Appendix B with the intention of providing goodness-of-fit measures. The shown specifications successfully explain between 40 to 50 per cent of the variation in hours of work lost in spite of the simplicity of the functional form and the few variables.

3.2 A tool for use in disaster contexts

Coming up with reliable figures on employment losses after an earthquake is crucial for coordinating the efforts of governments, donors, NGOs and international organizations. The quicker these figures are produced the sooner aid would reach affected families. Unfortunately, earthquakes generate a period of confusion that will likely overwhelm local authorities. If, on top of the extra workload the labour market suffers from informality as it is the case in the Turkish region affected by the 2023 earthquakes (with subregional informality rates ranging between 30 to 40 per cent), having access to alternative methodologies is of crucial importance so as to assess the actual impact of the disaster on the labour market.

Such an alternative methodology ought to be as simple as possible - gathering information is time consuming- and with variables likely to have a similar meaning in different contexts. This section presents a rapid assessment tool based on Equation 1 but modified based on the knowledge acquired in previous tests so as to reduce, as much as possible, data requirements. Based on the lessons learned, the proposed tool candidate is specified at the district level and not at the neighborhood level. This decision is taken based on the stronger statistical relationship between district level damage and employment losses and the additional difficulty of gathering disaggregated data for hundreds, perhaps thousands of affected neighborhoods. At the district level the degree of urbanization is not available, yet it is substituted for population density with thresholds at 100 and 500 people per km^2 following Vala (2004). The new specification becomes

$$l = \Phi(\beta_0 + \beta_1 d1 + \beta_2 d2 + \beta_3 d3 + \beta_4 \text{informal} + \beta_5 \text{agri} + \beta_6 \text{agri}^2 + \beta_7 \text{medium} + \beta_8 \text{high}), \quad (2)$$

where l represents the share of working hours lost at the district level and $d1$, $d2$ and $d3$ represent, respectively, the share of buildings with heavy damage, buildings to be demolished soon and collapsed buildings also at the district level. In turn, $informal$ represents the share of unregistered workers and $agri$ represents the share of employment in the agricultural sector. Two levels of population density, medium (100-500 people per km^2) and high (more than 500 people per km^2) are also added keeping low density as the reference. Importantly, it should be noted that no geographical dummy is included to avoid adding information that cannot be translated into something meaningful elsewhere.

Four specifications with decreasing data requirements are estimated in Table 7 using a fractional regression model and in Appendix B for their linear regression model counterparts. All parameters, including the intercepts, are shown so that they can be used to predict employment losses in the event of an earthquake. The information requirements can be adapted based on the local context. The preferred specification, which counts with information on population density, the local employment structure and three types of building damages may not be suitable in all contexts. As such, an specification without the employment structure, a third one with only building damage and a fourth one with only the share of collapsed buildings are also presented. In fact, the three damage types (heavy damage, buildings to be demolish soon and collapsed buildings) were, in principle, recorded by UNOSAT during the 2023 February earthquakes, and, thus, it could be argued that information at all 3 levels could have been gathered thanks to these satellite images.[12] Still, in the event that such information is not available, manually gathering data on collapsed buildings from satellite images would be a doable alternative which was also available few days after the 2023 February earthquakes

[12] See https://experience.arcgis.com/experience/af8529245dbb4041ba532fab46ee02d2/page/UNOSAT/?views=Layers for the work of UNOSAT in identifying damaged buildings for the Türkiye-Syria earthquake. Three categories were added based on the level of damage, yellow, orange and red for collapsed buildings.

thanks to MAXAR satellite images.[13]

Table 7: Fractional regression - District level results.

Variable	Spec.1	Spec.2	Spec.3	Spec.4
Heavy damage	4.35***	3.40***	3.15***	
To be demolish	11.50***	10.44**	13.35***	
Collapsed	−3.05*	−0.18	−1.54	9.79***
Informal	0.025***			
Agriculture	0.05			
Agriculture^2	−0.018			
Low density, reference				
Medium density	0.36**	0.24*		
High density	0.38**	0.30*		
Constant	−2.51***	−1.44***	−1.20***	−0.83***
Pseudo-R^2	0.0893	0.0775	0.0711	0.0398
Observations	24			

Significance: *** at 99%, ** at 95%, * at 90%.

All four specifications are estimated using the 24 districts for which information on employment losses exist. Based on the estimated models, damage, in all its forms, is always able to explain a significant part of the variation in employment losses. Indeed, according to the linear regression counterparts estimated in Appendix B (district level table) the explained variation goes from 34.9 per cent when exclusively using the share of collapsed buildings to 72.9 per cent when using all three degrees of damage, population density and information on the employment structure. It is worth noting that population density and the variables associated to the employment structure enter the model linearly. This is not realistic in the sense that a district with no damage would still showcase significant employment losses, hence why it is not advisable to use the tool in districts with little damage. In this sense a 5 per cent threshold is advised since no district with actual employment losses data suffered less damage. In spite of its potential drawbacks, and given the fact that the tool is only intended for use in disasters' contexts, a simpler functional form is preferred over more complex specifications that include, perhaps, harder to interpret interaction terms. Moreover, an alternative solution such as estimating separate equations for districts with different levels of damage is out of question due to the limited sample size.

3.3 Tool application and validation

The ILO/IOM household survey is able to provide estimates on employment losses at the provincial level as well as for capital/non-capital districts for the four most affected provinces. This section uses these estimates to tests the diagnostic tool, and, thus, assess its comparability with the ILO/IOM

[13] Please, see https://www.maxar.com/open-data/turkey-earthquake-2023.

estimates. Moreover, the ILO/IOM survey is not designed to create employment losses estimates at the district level nor it is designed to estimate other provinces' employment losses. This section goes futher than the ILO/IOM survey by generating shares of hours of work lost at the district level including key districts in provinces not covered by the survey (Gaziantep, Kilis and Osmaniye). It is important to note that the model estimates *shares* of hours of work lost. It is, thus, necessary to know how people were working before the disaster or at least to have a reliable estimate so as to come up with figure on FTE losses. This data is gathered from the ILO/IOM survey's recall module.

Model prediction. The district level exact figures on FTE losses as well as on the share of hours of work lost after the earthquake are shown in Appendix D. The information is provided in a table as well as in two maps. Moreover, and for informative purposes, province and global FTE losses are shown in Table 8. Even though not all the affected provinces are included in the analysis, the small extent of the damages attested in the ones missing allow us to quantify the short-term employment losses induced by the 2023 February earthquakes above the 400,000 FTE jobs mark with a quarter of the losses concentrated in the central districts of Hatay, namely the Antakya and Defne districts.

Table 8: Model prediction, FTE losses, by province.

Province	FTE losses	Province	FTE losses
Hatay	185,657	*Gaziantep*	24,158
Adıyaman	59,226	*Osmaniye*	20,586
Kahramanmaraş	58,480	*Kilis*	2,171
Malatya	40,657		
Total		389,029	

Note: The table shows full-time equivalent (FTE) employment losses by province and the total for the seven provinces for which a prediction is made. Only districts where at least 5 per cent of the buildings were lost are included in the out-of-sample prediction. This is due to a lack of common support, and, thus, of reliability. As a result eight (of the 19) districts from Gaziantep, Kilis and Osmaniye were excluded.

The importance of identifying high density areas is brought to the spotlight when comparing shares and total figures. Some districts from the north of Kahramanmaraş and the west of Malatya (near the epicenter of the second earthquake and not far from the epicenter of the first one) that sustained very heavy damage actually do not seem to pose much of a priority in terms of employment losses (see 3) due to their rural or semi-rural nature. Likewise, the metropolitan area of Kahramanmaraş, a city with a lower share of unusable buildings than other nearby districts showcases far larger FTE losses. The reason behind this result is merely the numbers. The metropolitan area of Kahramanmaraş holds approximately 600,000 people. As such, FTE losses are more meaningful to use than shares of employment losses when allocating humanitarian aid as well as setting up development projects. The sheer numbers would ensure a more efficient allocation of resources.

Tool validation. The performance of the tool application to Türkiye is assessed against aggregate estimates from the ILO/IOM survey. The survey contains survey weights to generate estimates on the share of hours of work lost at the aggregate level (4 most damaged provinces) and for central and non-central districts. These survey estimates are shown in the central column of Table 9 for all provinces, at the provincial level and within each province for central and non-central districts. Comparable estimates are produced with the full specification shown in Table 7 of the diagnostic tool introduced in Equation 2.

The comparison between the fully saturated specification used and the ILO/IOM survey is regarded as positive given the fact that a Kolmolgorov-Smirnov test cannot reject that the estimates shown in Table 9 are not generated by the same distribution.[14] Tests aside, the fact that the model is able to pick up the high share of hours of work lost in Hatay (64.6 per cent estimated by the tool and 59.8 by the survey) and Adiyaman (50.0 per cent estimated by the tool and 50.1 by the survey) central districts is also regarded positively as it would have allowed aid to flow to places where it was most needed.

Table 9: Hours of work lost estimates: Diagnostic tool vs. weighted survey data

Province	*Area*	Diagnostic tool	ILO/IOM survey	Difference
Adıyaman	*Central district*	50.0	50.1	−0.1
	Other districts	33.8	26.8	7.0
	Both	42.2	37.5	4.7
Hatay	*Central districts*	64.6	59.8	2.8
	Other districts	29.3	31.7	−2.4
	Both	43.2	42.5	0.7
Kahramanmaraş	*Central districts*	15.1	14.2	0.9
	Other districts	28.3	19.7	8.6
	Both	19.9	16.2	3.7
Malatya	*Central districts*	28.0	21.9	6.1
	Other districts	23.5	16.6	6.9
	Both	27.3	20.9	6.4
All four provinces		33.9	30.8	3.1

Notes: The table shows shares of hours work lost predicted by the diagnostic tool using district level data and the full specification. It also shows hours of work lost as predicted by the ILO/IOM survey for comparison.

In addition, the tested specification did not alter the ranking of employment losses attested at the provincial level even though it does not use provincial dummies and the specification is rather simple. Not all the estimates are as close as it would have been desired, though, especially the ones regarding non-central districts, which tend to be slightly overestimated. However, given the smaller population inhabiting non-central districts and the fact that earthquakes are urban phenomena (in terms of damage), the just mentioned overestimation is interpreted as of lower importance. For these

[14] The combined p-value is 0.570 which rejects the distributions are different.

reasons, it is concluded the diagnostic tool can be used at aggregate, provincial and province capital levels when evaluating the impact of future disasters originated by an earthquake.

4 Conclusions

The importance of generating reliable estimates regarding the impact of disasters is crucial from the humanitarian point of view as it allows donors to understand the extent of the tragedy and allows aid to be fast tracked to where it is needed the most. This article contributes to the literature on post-disaster assessment tools by creating one that predicts the share of hours of work lost after an earthquake. The diagnostic tool takes advantage of the relationship between building damage and employment losses using data collected during the 2023 February earthquakes that happened in south-eastern Türkiye. The wealth of administrative data regarding building damage and the existence of a post-earthquake household survey in the area allows for such tool to be crafted and the relationship between damage and employment to be examined in detail.

Based on the results, it stems that building damage and employment losses are strongly linked, although not all measures fare equally well. Among the three area levels examined, neighborhood, extended neighborhood and district level data, it is found that district level data is the most successful measure in terms of predicting power. Districts generally comprise a city and its surrounding rural areas; it is therefore concluded that smaller area measures of damage may not ensure commercial areas have suffered enough to put employment in peril. Likewise, broader (ie provincial) area measures of damage may reflect changes away from the city and, thus, have a low correlation with local employment levels. The damage typology is also examined, concluding that collapsed buildings are the weaker predictor in comparison with buildings that are not habitable yet remain in place. It is thought that the reason lies on the fact that employment losses can only be estimated for survivors and collapsed buildings are likely related to deceased individuals.

On top of building the tool, the tool is applied to the Türkiye February 2023 earthquake area with the intention of testing its performance against representative data from the ILO/IOM survey. The diagnostic tool is able to pick up the main trends as well as to closely mimic the central districts' employment losses for the four provinces for which representative survey data exists. In addition, the tool is used to predict employment losses at the district level. These estimates go further than available estimates prepared by the ILO/IOM survey by showing the hours of work lost for 68 districts. We show, among other results, than just Antakya may have endured 79,573 full-time equivalent job losses in the aftermath of the disaster.

In terms of features, the simplicity of the tool, the fact that it is estimated with data from both, rural and urban areas, the mixed economic activities carried out in these provinces (with manufacturing, services and agriculture all having significant shares of employment) and the existence of a moderate degree of informality in the labour market, makes it suitable to be used in future disasters in relatively different contexts.

This research does not come without limitations; the small sample size would benefit from similar future assessments with the idea of having a larger database regarding employment and damage. In addition, future research could benefit from identifying commercial areas in urban areas as well as from more disaggregated information on employment related variables such as informality. Last but not least, the tool developed in this article may not predict well the impact of even larger earthquakes and, likewise, we do not recommend its use in areas where damage is less than five per cent of the buildings' stock.

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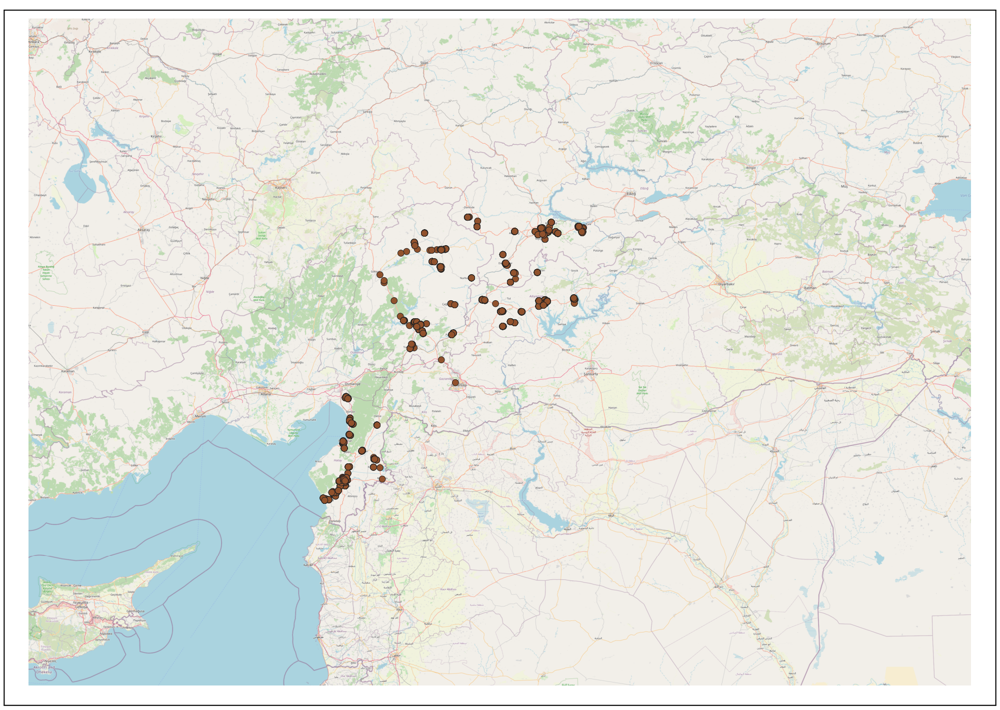
Appendix A - ILO/IOM Household survey.

The ILO, in partnership with IOM, embarked in February/March 2024 on a household survey in the earthquake area. The aim of the survey is to gather information on the working and living conditions of the earthquake survivors. As such, modules for housing, displacement, intention to migrate in the future, employment and unemployment, including a recall module regarding the labour force status before the earthquake can be found in the data.

In terms of sample size the survey interviewed 3,749 families made of 13,554 individuals representing 4,003,312 inhabitants of Hatay, Adıyaman, Kahramanmaraş and Malatya. The exact location of the visits is shown in Figure 1. The total population in the area is taken from Turkstat as of December 2023 and is deemed close enough to the date of the survey. The survey used stratified two-stage cluster sampling. Twenty strata were first identified, 5 per province, of which one belongs to container areas and the remaining four to normal housing areas (high/low damage in rural/urban areas). Then neighborhoods/container areas are chosen at random in each of these clusters and a random sample of households is finally selected. The survey was designed to have a sufficient sample size at the provincial level as well as for container areas/normal housing areas and capital/non-capital districts.

Figure 1: Interview locations



Source: Open street maps (OSM) and ILO/IOM survey data. *Notes:* The map shows the places where the 3,749 interviews took place.

Appendix B - Linear regression results.

Table 10: Neighborhood level.

Damage level	*Variable*	Spec.1	Spec.2	Spec.3	Spec.4
Neigh.	*Unusable*	0.14	0.14	0.31	0.22*
	Unusable^2			−0.08	
	Low density, reference				
	Medium density		−0.003		
	High density		0.15*		
	Agriculture	−0.016			
	Agriculture^2	0.00031			
	Informal				0.007
	Adjusted R^2	0.1636	0.1634	0.0477	0.0890
Ext. Neigh.	*Unusable*	0.51***	0.47***	0.89***	0.54***
	Unusable^2			−0.39**	
	Low density, reference				
	Medium density		0.016		
	High density		0.12*		
	Agriculture	0.0066			
	Agriculture^2	−0.0005			
	Informal				0.005
	Adjusted R^2	0.3004	0.3303	0.3323	0.2868
District	*Unusable*	1.10***	0.90***	0.65	0.95***
	Unusable^2			0.60	
	Low density, reference				
	Medium density		0.07		
	High density		0.14***		
	Agriculture	0.028*			
	Agriculture^2	−0.0014**			
	Informal				0.005
	Adjusted R^2	0.4839	0.4582	0.4256	0.4389
	Observations		44		

Significance: *** at 99%, ** at 95%, * at 90%.

Table 11: District level results.

Variable	Spec.1	Spec.2	Spec.3	Spec.4
Heavy damage	1.44^{***}	1.16^{**}	1.09^{**}	
To be demolish	4.38^{*}	3.82^{*}	4.97^{**}	
Collapsed	-1.15	-0.17	-0.64	3.41^{***}
Informal	0.009^{**}			
Agriculture	0.017			
Agriculture^2	-0.00068			
Low density, reference				
Medium density		0.08		
High density	0.11^{*}	0.11		
Constant	-0.35^{**}	0.015	0.07	0.19^{***}
Adjusted R^2	0.7294	0.6420	0.6147	0.3490
Observations	24			

Significance: *** at 99%, ** at 95%, * at 90%.

Appendix C - Sample size checks.

The choice of how many respondents is enough to include a neighborhood in the analysis is rather trivial. In the article we consider that having 14 individual responses is reasonable to include a neighborhood in the analysis but an upwards change to further avoid cases of extreme variability could also be interest. The idea of this appendix is to show the results that arise from having 19 respondents (34 neighborhoods in the sample) per neighborhood as a robustness check.

Table 12: Neighbourhood level results - Sample size change.

Damage level	*Variable*	Spec.1	Spec.2	Spec.3	Spec.4
Neigh.	*Unusable*	0.67	0.60	1.38	1.00**
	Unusable^2			−0.40	
	Low density, reference				
	Medium density		−0.29		
	High density		0.23		
	Agriculture	−0.05			
	Agriculture^2	0.0011			
	Informal				0.017*
Ext. Neigh.	*Unusable*	1.77***	1.62***	4.30**	1.91***
	Unusable^2			−3.72	
	Low density, reference				
	Medium density		−0.18		
	High density		0.20		
	Agriculture	0.005			
	Agriculture^2	−0.0008			
	Informal				0.010*
District	*Unusable*	3.23***	2.79***	2.88	2.92***
	Unusable^2			0.27	
	Low density, reference				
	Medium density		0.06		
	High density		0.34*		
	Agriculture	0.07**			
	Agriculture^2	−0.004***			
	Informal				0.015*
Observations			34		

Significance: *** at 99%, ** at 95%, * at 90%.

Appendix D - Türkiye application.

Table 13: District level results, impact on employment.

		Losses				*Losses*	
Province	District	*FTE*	*Share*	Province	District	*FTE*	*Share*
Adıyaman	Merkez	36,575	50.0	Kahramanmaraş	Dulkadiroğlu	12,371	19.7
	Besni	4,695	29.0		Onikişubat	16,175	12.8
	Çelikhan	1,193	38.3		Afşin	3,652	21.5
	Gerger	927	28.1		Andirin	844	12.7
	Gölbasi	3,754	35.5		Çağlayancerit	979	20.6
	Kâhta	8,798	32.5		Ekinözü	795	40.6
	Samsat	429	30.6		Elbistan	4,760	15.8
	Sincik	1,977	59.1		Göksun	5,193	48.2
	Tut	872	44.3		Nurhak	1,609	61.8
					Pazarcık	4,929	33.1
Hatay	Antakya	79,563	66.4		Türkoğlu	7,168	42.7
	Defne	30,044	60.4				
	Altınözü	6,567	47.0	Malatya	Battalgazi	15,992	26.9
	Arsuz	4,711	20.1		Yeşilyurt	19,137	28.9
	Belen	1,771	22.2		Akçadağ	1,466	35.8
	Dörtyöl	6,153	20.6		Arapgir	108	7.4
	Erzin	1,800	18.7		Arguvan	124	12.3
	Hassa	3,886	29.6		Darende	593	16.4
	İskenderun	14,443	24.8		Doğanşehir	2,136	42.8
	Kırıkhan	11,665	41.7		Doğanyol	48	8.8
	Kumlu	796	25.8		Hekimhan	242	10.5
	Payas	1,466	20.3		Kale	87	10.7
	Reyhanlı	5,468	21.8		Kuluncak	104	10.2
	Samandağ	15,322	53.7		Pütürge	239	13.0
	Yayladağı	1,394	16.4		Yazıhan	374	21.3

Notes: The table shows Full Time Equivalent (FTE) employment losses as well as the share of hours of work lost after the earthquake at the district level (LAU1). The results are predictions using the main specification, see section 3.1.

Figure 2: Model prediction, share of working hours lost, by district

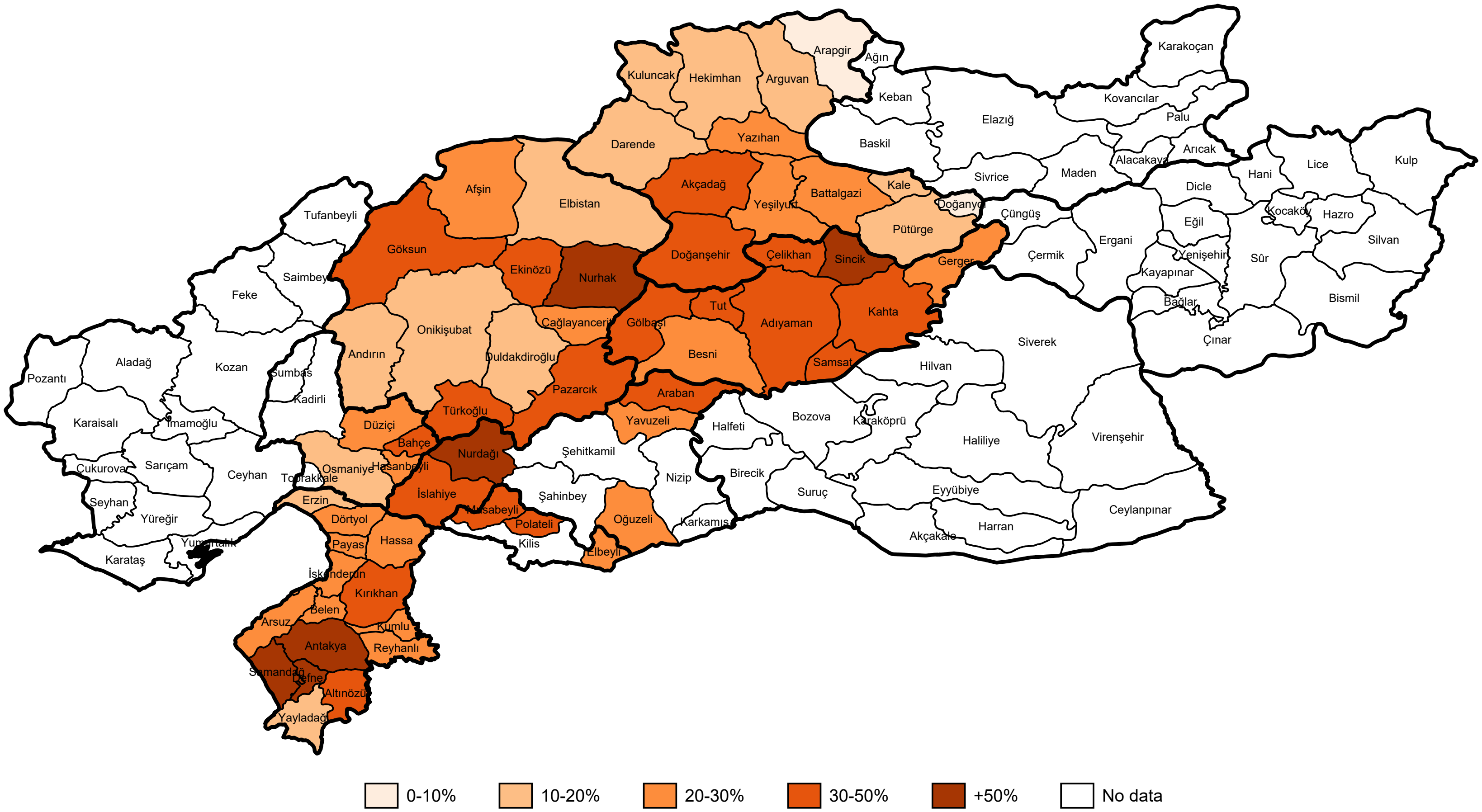


Figure 3: Model prediction, FTE losses, by district